SALMON RECOVERY SCIENCE REVIEW PANEL
Report for the meeting held
December 4-6, 2000
Northwest Fisheries Science Center
National Marine Fisheries Service
Seattle, Washington

Robert T. Paine	**University of Washington, chair**
Ted Case	**University of California – San Diego**
Fran James	**Florida State University**
Si Levin	**Princeton University**
Russ Lande	**University of California – San Diego**
Bill Murdoch	**University of California – Santa Barbara**
Beth Sanderson	**National Marine Fisheries Service liaison** **RSRP report coordinator**

Recovery Science Review Panel

The Recovery Science Review Panel (RSRP) was convened by the National Marine Fisheries Service (NMFS) to help guide the scientific and technical aspects of recovery planning for listed salmon and steelhead species throughout the West Coast. The panel consists of six highly qualified and independent scientists who performs the following functions:

1. Review core principles and elements of the recovery planning process being developed by the NMFS.

2. Ensure that well accepted and consistent ecological and evolutionary principles form the basis for all recovery efforts.

3. Review processes and products of all Technical Recovery Teams for scientific credibility and to ensure consistent application of core principles across ESUs and recovery domains.

4. Oversee peer review for all recovery plans and appropriate substantial intermediate products.

The panel meets 3-4 times annually, submitting a written review of issues and documents discussed following each meeting.

Expertise of Panel Members

Common to many/all panel members:
- Involvement in local, national and international activities
- Participation in National Research Council activities
- Service on multiple editorial boards
- Numerous publications in prestigious scientific journals

Dr. Ted Case
- University of California- San Diego
- *Field of expertise*: evolutionary ecology, biogeography and conservation biology
- *Awards*: Board member for National Center for Ecological Analysis and Synthesis; Research featured in prominent scientific journals (Science, Nature) popular science journals (American Scientist, Discover), on public television and public radio
- *Scientific leadership*: Chair of department of Biology at UCSD and author of leading textbook on theoretical ecology;
- *Research*: More than 116 scientific articles published

Dr. Frances C. James
- Florida State University
- *Field of expertise*: conservation biology, population ecology, systematics, ornithology
- *Awards*: Eminent Ecologist Award (Ecological Society of America); Leadership and dedicated service awards from the American Institute of Biological Sciences
- *Scientific leadership*: Participant on National Research Council Panels; service on many editorial boards; Board of Governors for The Nature Conservancy; scientific advisor for national, state and local activities;
- *Research*: More than 105 scientific articles published

Dr. Russell Lande

- University of California-San Diego
- *Field of expertise*: evolution and population genetics, management and preservation of endangered species, conservation and theoretical ecology
- *Awards*: Sewell Wright Award (American Society of Naturalists); Fellow - John Simon Guggenheim Memorial Foundation, MacArthur Foundation, American Academy of Arts and Sciences
- *Scientific Leadership*: President of the Society for the study of Evolution; International Recognition; developed scientific criteria for classifying endangered species adopted by the International Union for Conservation of Nature and Natural Resources (IUCN)
- *Research*: More than 116 scientific publications

Dr. Simon Levin

- Princeton University
- *Field of expertise*: theoretical/mathematical ecologist
- *Awards*: National Academy of Sciences member; Robert H. MacArthur award recipient from the Ecological Society of America; Statistical Ecologist Award from the International Association for Ecology; Distinguished Service Award from the Ecological Society of America
- *Scientific leadership*: Member of many National Research Council panels; Board of Director member for Santa Fe Institute, Beijer International Institute of Ecological Economics, The Committee of Concerned Scientists
- *Research*: More than 275 technical publications

Dr. William Murdoch

- University of California Santa Barbara
- *Field of expertise*: theoretical and experimental ecologist, population ecology
- *Awards*: Robert H. MacArthur award recipient from the Ecological Society of America; President's Award from the American Society of Naturalists; Guggenheim Fellowship
- *Scientific leadership*: Founder of National Center for Ecological Analysis and Synthesis; Director of Coastal California Commission 10-year study; National Academy of Sciences committee member; scientific advisory panel member for the Habitat Conservation Plan for the California marbeled murrelet
- *Research*: More than 118 scientific publications

Dr. Robert Paine (chair)

- University of Washington
- *Field of expertise*: marine community ecology, complex ecological interactions, natural historian,
- *Awards*: National Academy Sciences member; Robert H. MacArthur award recipient from the Ecological Society of America; Tansley Award (British Ecological Society); Sewell Wright Award from the American Society of Naturalists
- *Scientific leadership*: Member of multiple National Research Council panels, editorial boards, past president of Ecological Society of America
- *Research*: More than 100 scientific publications

Dr. Beth Sanderson

- National Marine Fisheries Service liaison to the Recovery Science Review Panel
- Recovery Science Review Panel report coordinator

SALMON RECOVERY SCIENCE REVIEW PANEL
Seattle, December 4-6, 2000

I. OVERVIEW

II. MODELS

a. Styles of models and their underlying philosophies
b. Competing models and recovery strategies
c. Criteria for extinction risk assessment
d. Summary

III. BIOLOGICAL INFLUENCES ON SALMON SMOLTS

IV. ADVICE TO TRTS

V. FUTURE TOPICS

VI. REFERENCES

SALMON RECOVERY SCIENCE REVIEW PANEL
Seattle, December 4-6, 2000

I. OVERVIEW

The full committee [Case, James, Lande, Levin, Murdoch and Paine] met at the Northwest Fisheries Science Center. The appended agenda identifies our three primary foci: a full day committed to the Puget Sound and Oregon TRTs; an equivalent time spent on two contrasting modeling styles [Ecosystem Diagnosis And Treatment (EDT) and Plan For Analyzing And Testing Hypotheses (PATH)]; and a half day being informed about biologically-based sources of mortality, either potential or realized, of Columbia Basin salmonids. This report concentrates on the latter two elements because it is clear that it is premature to evaluate "progress" towards unified restoration plans of the two TRTs. Instead, in keeping with our self-perception that the RSRP can be of greatest value to NMFS by being holistic and identifying the highest quality and most appropriate science, in a management and salmonid recovery sense, we focus these comments on MODELS necessary to develop a unified context in which problems and data gaps can be identified and restoration strategies compared, and ecological INTERACTIONS which could influence salmonid mortality schedules.

II. MODELS

A. STYLES OF MODELS AND THEIR UNDERLYING PHILOSOPHIES

The management of natural populations is an exercise in quantitative science; hence mathematical models are essential and invaluable tools. However, they must be used wisely and with understanding of limitations. Fisheries biology, in particular, has been a a rich breeding ground for mathematical descriptions ever since the great mathematician Vito Volterra turned his attention to the fluctuations of the Adriatic fisheries. Volterra's models were simple in structure, but complex in dynamics; this duality made them powerful aids in understanding key features of complex population fluctuations. Years later, William Ricker, perhaps the most innovative and influential of fishery scientists, showed how fairly simple age-structured models of fish populations could exhibit even more complicated dynamics (Ricker 1954); indeed, his simulations were probably the first demonstrations in ecology of chaotic population dynamics, whose importance was clarified twenty years later in a landmark paper of Robert May (1974).

The lessons of these seminal studies are inescapable: Models can play a fundamental role in demonstrating the mechanisms underlying observed phenomena, but even simple models can have complicated dynamics. The more complex models become, the more easily one can twist them to do almost anything, and the less reliable they become. Ludwig and Walters (1985) explored these truths in detail for fishery models in particular, taking into account explicitly the problems associated with parameter estimation. Their work demonstrated that, although models must include enough detail to capture the essential, unique aspects of a problem, too much detail can render models useless. The key to intelligent modeling is to find the optimal level of detail and to suppress confounding statistical noise. This is basically the approach that has worked so effectively in physics, in which statistical mechanical methods allow one to capture robust macroscopic features in terms of the collective dynamics of large numbers of unpredictable parts. This is the only approach that makes sense for modeling large-scale, intrinsically complex and dynamic systems.

The conclusions to be derived are that large-scale models that attempt to capture the dynamics of many species, or that rely upon the measurement of massive numbers of parameters, are doomed to failure. They substitute sledgehammer simulation for analytical investigation and efforts to identify the few key driving variables. Large models are bedeviled by problems of parameter estimation, the representation of key relationships, and error propagation. When the phenomena are fundamentally non-linear, this leads naturally to path dependence and to sensitivity of results to parameter estimates. As the number of parameters increases, the potential for mischief increases. Thus it is essential to rid models of irrelevant parameters, and to identify key relationships. It also emphasizes the importance of locating what aspects of the model are most likely to lead to the expansion of error, and to focus on representing these as accurately as possible. This can only be done reliably through data-driven methods, with attention to appropriate statistical methodology.

When the data are not available for the needed estimates of parameter values, there is a tendency to insert values based on opinion or expert testimony. This practice is dangerous. The idea that opinion and "expert testimony" might substitute for rigorous scientific methodology is anathema to a serious modeler and clearly represents a dangerous trend. Indeed, there are limitations even to what can be done on the basis of data: the fact that relationships are often nonlinear, and further that interest often rests on understanding the behavior of populations beyond the range of variables that has been observed, creates vexing problems for the modeler. It provides a compelling argument for experimentation in order to elucidate underlying mechanisms, for the recognition of limits to predictability, and for the use of adaptive assessment and management (Ludwig and Hilborn 1983; Holling 1978).

EDT is a case study of the problems just discussed. The current version which uses 45 habitat variables might be a useful list of things to consider, but the incorporation of so many variables into a formal model renders the predictions of such a model virtually useless. Even more vexing is that EDT depends upon a large number of functional relationships that are simply not known, (and cannot be known adequately) and yet they play key roles in model dynamics. The inclusion of so much detail may creates an unjustified sense of accuracy; but actually it introduces sources of inaccuracy, uncertainty and error propagation. Subjective efforts to quantify these models with "expert opinion" compound these ills.

B. TWO COMPETING MODELS AND RECOVERY STRATEGIES

The two current major models concerning salmon population dynamics and its estimated sensitivity analysis to different management scenarios, i.e., PATH and CRI, have different strengths and weaknesses. Path uses retrospective analyses to estimate mortality of salmon at various stages and prospective decision analyses to obtain management recommendations. It fits many more parameters than does CRI. PATH incorporates environmental stochasticity, but not demographic stochasticity, and there is no absorbing barrier for extinction (i.e., stocks can get infinitely close to zero and still bounce back. This feature forces the criteria for survival and recovery to be unconventional and awkward. CRI (Kareiva et al. 2000) has fully explicit age structure, but does not incorporate stochasticity. In its simplicity CRI is much more transparent than PATH. STUFA (State, Tribal and US Fisheries Agencies) (Oosterhout et al., Draft) is a modified CRI model, one version of which incorporates environmental stochasticity, but not demographic stochasticity. STUFA helps to clarify differences between CRI and PATH by modifying parameter values to meet different assumptions. The different conclusions from current versions of these models appear to arise at least as much from different assumptions about parameter values as from structural differences in the models. One pivotal source of model disagreement concerns the magnitude of "indirect " or "deferred" mortality that smolts may experience from the hydroelectric system, either from dam passage or from barging around dams. Controlled experiments with natural passage vs. barging of hatchery fish down certain rivers without dams could help to resolve these differences by allowing direct measurement of delayed mortality from barging, which could then be used to calibrate the extra mortality from dam passage, by comparison to barging down rivers with dams.

In contrast, the EDT model seeks to characterize habitat quality by incorporating extensive habitat variables and their effects at multiple stages of the salmon life history. It suffers from severe overparameterization and opaqueness. Because it relies on expert opinion to determine parameter values it takes a more subjective approach. It appears impossible to validate this model by observations or experiments and difficult to pinpoint specific structural features or parameter assignments that might explain deviations from expected responses so as to improve model performance over time. It is well known that models with a small to intermediate number of parameters generally provide the best predictive power. One method for deciding when to include additional parameters in a model uses the Akaike Information Criterion (Burnham and Anderson 1998) and we encourage its application.

C. QUALITATIVE, OBJECTIVE CRITERIA FOR EXTINCTION RISK ASSESSMENT

For most salmon populations there are insufficient data to quantify accurately extinction risk based on stochastic modeling of population viability (measured as probability of extinction within a 100 years). For such situations, or when competing quantitative population models reach fundamentally different conclusions, the IUCN (International Union for the Conservation of Nature) has developed qualitative, objective population-based criteria to classify extinction risk that have been applied to thousands of taxa (IUCN 1994). Mace (1994) describes the process by which these criteria were developed and validated. NMFS should develop such criteria for classifying extinction risk of salmon populations and apply them to all identified populations within each listed and unlisted ESU, starting from criteria used by IUCN (1994 or later) and those suggested by Allendorf et al. (1997). These qualitative classifications could be checked against quantitative Population Viability Analysis for the relatively small number of populations that have the best data available to develop stochastic population models (e.g. Ratner et al. 1997). Particular attention should be given to separating components of variance in population size due to sampling error, demographic stochasticity, and environmental stochasticity (Engen et al. 1998, Saether et al. 1998, 2000). Also, the results in terms of persistence times or probability of survival will be sensitive to assumptions about the strength of positive (or negative) density dependence at low densities, and we know practically nothing about how strong that might be, despite the largely negative results of Myers et al. (1995), which could be due to undersampling of populations at very low densities.

D. Summary

NMFS should aim for the construction of the simplest possible models that contain the major driving mechanisms. To the extent possible, the models' functions and parameters should be based on data and known ecology, and should be sufficiently transparent that each component is in principle subject to testing against real data, and subsequent modification.

EDT exemplifies how modeling should not be done. It is overparameterized, includes key functional relationships that cannot be known and cannot be tested, creates a false sense of accuracy, yet introduces error and uncertainty. Its very complexity makes it difficult to determine the effect of various assumptions and parameter values on the model's behavior and relation to data. The attempt at quantification through subjective "expert opinion" compounds these fatal weaknesses, especially the model's inability to confront and improve with confrontation of data.

The CRI model offers the possibility of direct confrontation with data. We recommend a continual development of various modeling approaches in combination with experiments, particularly experiments involving barging, to resolve a key issue – the size of indirect or deferred hydroelectric-induced mortality smolts suffer as they move downstream.

III. BIOLOGICAL INFLUENCES ON SALMON FRY AND SMOLTS

The committee heard four presentations giving details on biological factors that might influence salmon recovery. We comment on these here both because such studies identify potentially significant but incompletely understood sources of salmon mortality, but also because they exemplify the experimentally tractable, question-driven research which we believe is essential if management decisions and restoration efforts are to be informed by biological research.

* Mary Moser. She discussed the American Shad, a non-indigenous species introduced to the Columbia river before 1870 and now firmly established in all appropriate systems in coastal, western North America. These anadromous fishes are now more abundant in the Columbia than salmonids. There are ample reasons to suspect mechanisms through which they might negatively impact chinook and sockeye ESUs. Shad make their spawning runs in May-July and thus overlap in timing with summer run chinook. The exact timing of shad runs at dams allows a "clutter effect" [in which shad block fishways and thus thwart migrating salmon] to be quantified. Two other biologically-based mechanisms may be equally significant. The millions of shad fry returning to the estuaries could help maintain higher generalist predator populations than otherwise possible. Second, small shad are planktivores, have substantial dietary and spatial overlap with salmonid smolts, especially in estuaries and thus during the physiologically challenging transition from fresh to marine water, and hence might compete with chinook stocks. Simply put, and in the absence of data, but especially because of the numbers of fish involved, NMFS should be encouraged to examine the possible consequences of shad-salmon interactions in detail.

* Phil Levin. He described brook trout-chinook salmon interactions in the Snake River watershed but placed the details into the broader context of non-indigenous species interactions with salmon, especially as they may impact the egg/smolt stages. Brook trout are now the third most common species in these watersheds. They overlap extensively in diet with native chinook, and grow large enough to pose a predation threat to salmon fry and smolts (Kreuger and May 1991, Maret et al. 1997). Furthermore, snorkel and electroshocking surveys, the latter coupled to pit tag studies, indicate significantly better salmon survival from systems in which brook trout are absent. Calculations translate this relatively enhanced survival into a three percent increase in per annum population growth (lambda). The work highlights three attributes the committee believes are imperative if a more complete understanding of the salmons' biological matrix is to be developed. 1]. The roles of non-indigenous [= introduced] species should neither be ignored nor underestimated. 2]. Watershed or larger bodies of water successfully invaded by non-native competitors or predators should not be labeled "pristine". And last, 3], the experimental tractability and the potential for some measure of control [both through electroshocking] in these shallow streams identify important data gaps relatively inexpensively filled, or techniques vastly less drastic than more extreme remediation measures.

* Two presentations [by Brad Ryan and Herb Pollard] concentrated on the salmonid-piscivorous bird relationship in the Columbia basin. We believe it critically important that NMFS coordinate research by state and other federal agencies [e.g., BPA] to quantify the ecological impacts of this relationship. 1]. Piscivorous bird populations [especially Caspian terns, double-crested cormorants, and "gulls"] are increasing throughout the Columbia basin, and at an estimated 10%/year in the estuarine areas. 2]. Although 100 million smolts survive dam passage and barging to reach the estuary, estimates of tern-caused mortality range from a conservative 2-4%/year based on pit tag recoveries to a high of 15%/year based on bioenergetic modelling. Such estimates do not include mortality due to cormorant predation [by perhaps 2600 pairs] or as many as 50,000 gulls. 3]. Remediation of tern effects has become litigious, and could serve as a harbinger of the

certain future challenges to NMFS salmon remediation attempts. Smolts of listed ESUs of spring chinook migrate downstream at a time that coincides with feeding maxima of tern chicks and fledglings. One estimate is that 38% of spring chinook smolts are eaten by birds. Migrating steelhead seem even more vulnerable than chinook to bird predation: minimal mortality estimates range from 10-15 % for steelhead in comparison to 2-4% for chinook.

The avian studies highlight three aspects of salmon decline that we believe NMFS should be especially sensitive and reactive to. 1]. The pit tag technology represents a powerful and underused tool for documenting stock-specific mortality rates and their biological causes. Thus such contentious issues as relative survival of barged and non-barged, and hatchery vs. wild stocks could be addressed quantitatively. 2]. Effective remediation (e.g., down-sizing or relocation of bird colonies) is possible though contentious. 3]. Better estimates of biologically-based, downstream salmon mortality could generate a perspective alternative to that of "hydro only" models, thereby enriching the mix of hypotheses of why certain salmon ESUs are in decline.

* Summary. We have emphasized the importance of smaller spatial scale, more mechanistic studies for two reasons. 1]. They have enormous potential for expanding the debate on the reasons for salmonid decline in the Columbia Basin by providing alternative though not necessarily antagonistic hypotheses. Further, such mechanism-oriented studies should apply, within limits, to restoration challenges throughout the entire geographic range of salmonids. 2]. They embody the type of experimental manipulation or application of newer technologies that ecologists are increasingly understanding and integrating into models of how complex systems function. What follows is a partial list of such endeavors suggested by presentations during our initial RSRP meetings that we believe will be important for NMFS to consider.

A. A fundamental requirement of CRI and other demographic models is adequate, quantitative estimates of life history parameters (i.e., life stage survival, growth, fecundity). Such data are currently available for very few stocks. A greatly expanded application of marking technology and monitoring may be capable of providing such information on the trajectories and fates of targeted salmon populations.

B. Resolving some of the suspected differences between hatchery and wild fish (e.g., straying) should be an early and essential target. The same might hold for the relative fates of barged and unbarged smolts in a river system without dams.

C. Further experiments or structured observations on bird impacts on migrating smolts are needed. A biological counterpart, on which we have received no information, is marine mammal predation on returning adult salmonids.

D. Study non-indigenous species as potential competitors [e.g., shad, successfully-introduced Atlantic salmon] or predators [e.g., brook trout, small and large mouth bass, wall-eye, squaw fish, pike, giant catfish in the Snake river, etc.]. It seems inappropriate to ignore these sources of extra mortality.

E. Study potential improvements to wild salmon habitat through controlled manipulations of nutrient supplementation (e.g., carcass additions) or specific modifications of in-stream conditions (e.g., addition of woody debris).

F. A major issue for research to resolve is the question of how much "deferred mortality" results from dams. Our suggested barging experiment would help to resolve this issue.

G. The committee recognizes that the above list only tangentially addresses critical issues of habitat quality/availability. The delisting of salmonid ESUs will require scientifically sound understanding of habitat-fish relationships.

IV. ADVICE TO TRTS

General Considerations on Population Designations And Delisting Criteria: Phase 1

The first job of the TRTs is to set biological criteria for delisting evolutionarily significant units (ESU), a technical exercise that requires identification of critical populations within each ESU, and estimating target abundances and viabilities, and integrating them up to the ESU level the Puget Sound TRT has already found that for chinook the genetic data and length-at-age data are concordant with a designation of populations on the basis of river basins and subbasins, at least for the northern area of Puget Sound. Categorization by stream flow patterns, ecoregions, and relative abundances of fish seem to be less useful. Elsewhere, defining populations as demographically nearly independent stocks within ESUs provides a nice conceptual format for subsequent viability analyses but in practice will be difficult to apply given the state of the existing data and the spatial correlation in environmental variables. We are pessimistic that populations can be deduced on estimated cross-correlations of population time series, as these generally have large statistical sampling errors due to shortness of most available time series (only a few decades) and substantial sampling errors of population estimates within years. In addition, even populations that exchange no migrants may be synchronized by regional environmental stochasticity and potential ecological interactions between different species or populations in shared ocean, estuarine or freshwater environments (e.g. Sutcliffe et al. 1996; Myers et al. 1997). A more practical method appears to be a qualitative definition based on river geometry and geographic distance, informed by data on population genetic distance where this is not seriously contaminated by hatchery releases, and measured or inferred straying rates of naturally spawned fish (not hatchery fish).

Specific Comments regarding Population identification

Additional data of two types might be useful in defining Viable Salmonid Populations (VSPs).

> *Historical population structure.* Museum specimens, and perhaps others collected in the past, may be available and able to provide genetic material to help determine the degree of historical genetic isolation of various populations. Specimens taken before, or early in the widespread use of hatcheries, would be especially useful. Sources of such specimens might include museums in academic zoology or fisheries departments, and the California Academy of Sciences. We recommend an initial survey of the most likely institutions to determine whether this is a worthwhile project.
>
> *Straying rates of wild salmon.* Currently, estimates of straying rates are based almost entirely on hatchery fish, which are thought to have higher straying rates. Although natural markers may be available in a few instances, it seems that tagging and recovery of wild salmon will be needed to get straying estimates for wild populations. We recommend concentrating tagging-recovery efforts on a limited number of the most promising and potentially representative populations, rather than spreading the effort widely. Recovery should also be focused, to the extent possible, in situations that give unambiguous information (e.g., upstream carcasses rather than downstream harvests).

Estimation of the effects of management actions and costs: phase 2

> The second job of the TRTs, to estimate the likelihood that corrective measures will be adequate and to set administrative delisting criteria that allow for societal values, is far more difficult than the first. Even with the acknowledged uncertainties about many populations, there will have to be estimates of the relative impacts of hydropower, hatcheries, harvest and habitat on abundance and productivity levels. Because the ultimate goal is to provide these estimates to managers so they can set watershed-level priorities, it is not too soon to start meeting with managers. As the TRTs proceed, they will probably identify what monitoring efforts need to be added to current work, what comparisons and experiments will be needed to strengthen inferences about causes of population declines, and what kinds of modeling will be required. It is unlikely that viability modeling like the current work on the Columbia basin chinook salmon will be possible for many other populations. Therefore alternative procedures should be explored. Simultaneously, as estimates of functional relationships become available, -say between egg-smolt survival, substrate characteristics, and water quality - increasingly rigorous models can be constructed.
>
> Mitigation and restoration efforts are underway in many areas of the Northwest: estuarine areas are being opened up to salmon, riparian zones are being purchased

and improved. With appropriate measurements and monitoring, these actions can provide data to test and improve models that seek to predict how a change in a habitat characteristic will affect salmon performance.

These comments suggest that the spatial scale of the models will be important. The scale should correspond with the size of units that are amenable for measuring habitat characteristics and changes in salmon performance, and with the size of units that are likely to be incorporated and/or manipulated in restoration actions. In the light of our comments earlier on the dangers of overly parameterized models, it will be best if the scale is much smaller than the range of environments used during the entire freshwater life cycle. Then input of salmon life stages developed elsewhere could be treated as an initial condition, so that a single model does not attempt to define the entire landscape/life history.

V. FUTURE TOPICS

- The panel intends to explore in depth the relationships between salmon ESUs and conservation and production hatcheries.

- It will be important to understand the status of ESUs in California. The panel expects to be informed about the status of populations and ESUs, hatchery production, habitat issues, and available data in the near future.

- What are the potential effects of Atlantic salmon farming on native salmonids (disease vectors, establishment of breeding populations, etc.)?

- How critical are estuaries as transition habitats to smolt survival?

- The committee should be informed about how near shore and oceanic conditions influence salmonid survival. For instance, must the ocean be considered a ‘black box’? Will a developing IDO (inter-decadal oscillation) change survival parameters sufficiently to alter model predictions? That is, is it possible that positive IDO changes will alter conditions from the current ‘too few native fish per unit of acceptable habitat’ to ‘too many’?

- The committee would like to meet with managers to hear the extent to which their activities could be planned in a way that will allow tests of ideas about the relative impacts of alternative management actions and how the science and the management can move forward together.

VII. REFERENCES

Allendorf, F. W., D. Bayles, D. Bottom, K. P. Currens, C. A. Firssell, D. Hankin, J. A. Lichatowich, W. Nehlson, P. C. Trotter & T. H. Williams. 1997. Prioritizing Pacific salmon stocks for conservation. Conservation Biology 11: 140-152.

Burnham, K. P. & D. R. Anderson. 1998. Model selection and inference. Springer-Verlag, New York.

Engen S, Bakke O, Islam A. 1998. Demographic and environmental stochasticity - Concepts and definitions. Biometrics 54: 840-846.

Holling, C. S. 1978 Adaptive Environmental Assessment and Management. Wiley New York.

IUCN. 1994. IUCN Red List Categories. IUCN, Gland, Switzerland.

Kareiva, P., M. Marvier, and M. McClure. 2000. Recovery and management options for spring/summer chinook salmon in the Columbia River Basin. Science 290:977-979.

Krueger C. C., B. May. 1991. Ecological and genetic effects of salmonid introductions in North America. Can. J. Fish, Aquat. Sci. 48 (Suppl. 1):66-77.

Ludwig, D. and Hilborn, R. 1983. Adaptive probing strategies for age-structured fish stocks Canadian Journal of Fish Aquatic Science 40:559-569

Ludwig, D. and Walters, C.J. 1985. Are age-structured models appropriate for catch-effort data? Canadian Journal of Fish Aquatic Science 42: 1066-1072

Mace, G. M. 1994. An investigation into methods for categorizing the conservation status of species. Pp. 293-312 in P. J. Edwards, R. M. May & N. R. Webb (eds.), Large-scale ecology and conservation biology. Blackwell, Oxford.

Maret T. R., C. T. Robinson, and G. W. Minshall. 1997. Fish assemblages and environmental correlates in least-disturbed streams of the Upper Snake River basin. Trans. Am. Fish. Soc. 126:200-216.

Mobrand Biometrics Inc. August 1999. The EDT method.

Myers R.A., Barrowman N.J., Hutchings J.A., Rosenberg A.A. 1995. Population dynamics of exploited fish stocks at low population levels. Science 269: 1106-1108.

Myers, R. A., G. Mertz & J. Bridson. 1997. Spatial scales of interannual recruitment variations of marine, anadromous, and freshwater fish. Canadian Journal of Fisheries and Aquatic Sciences 54: 1400-1407.

Oosterhout, G., P. Wilson, C. Petrosky, et al. Draft MS April 28, 2000. A technical review of the National Marine Fisheries Service Leslie matrix model of Snake River spring and summer chinook populations.

R. M. May. 1974. Biological populations with non-overlapping generations: stable points, stable cycles, and chaos. J. Theor. Biol. 49: 511-524

Ratner, S., R. Lande & B. B. Roper. 1997. Population viability analysis of spring chinook salmon in the South Umpqua River, Oregon. Conservation Biology 11: 879-889.

Saether BE, Engen S, Islam A, McCleery R, Perrins C. 1998. Environmental stochasticity and extinction risk in a population of a small songbird, the great tit. American Naturalist 151: 441-450.

Saether BE, Engen S, Lande R, Arcese P, Smith JNM. 2000. Estimating the time to extinction in an island population of song sparrows. Proc. Roy. Soc. Lond. B 267: 621-626.

Sutcliffe, O. L., C. D. Thomas & D. Moss. 1996. Spatial synchrony and asynchrony in butterfly population dynamics. Journal of Animal Ecology 65: 85-95.

W.E. Ricker. 1954. Stock and recruitment. Journal of Fisheries Research Board Canada 11: 559-623

----

13 February 2001

Recovery Science Review Panel Meeting
Tentative agenda; December 4-6, 2000

Monday	Tuesday	Wednesday
8:30 Welcome and Introduction	Meet with Technical Recovery Teams	
9:00 Introduced Species and Predators Peter Kareiva (overview) Mary Moser (shad) Phil Levin (Trout) Herbert Pollard (birds) Brad Ryan (terns/cormorants)	9:00 Viable Salmonid Populations 10 Break 10:15 Identifying Populations	
		11:00 – Productivity (Robin Waples)
12:00 Lunch w/ Dan Goodman (ISAB)	Lunch (will order sandwiches)	Lunch (Usha Varanasi and Mike Schiewe)
1:30 Ecosystem Diagnosis & Treatment Lars Mobrand (overview) Jim Scott (application of EDT)	1-3 Approaches to estimating viability 3:00 Break 3:15-4:15 Questions relating to habitat: introduction to the issues	***1:00 – PATH*** Jim Anderson Howard Schaller Dave Marmorek